Chapter 9

Project Management Raw Materials Surveys

Significance of raw materials assessment in planning and execution of a project

1. EXPLORATION PROCEDURE

The following paragraphs describe a procedure developed specifically for the exploration of cement raw material deposits. The proposed scheme is based on experience and modelled after the needs of the cement and aggregate industry. Of course, every exploration project requires modifications necessitated by local circumstances.

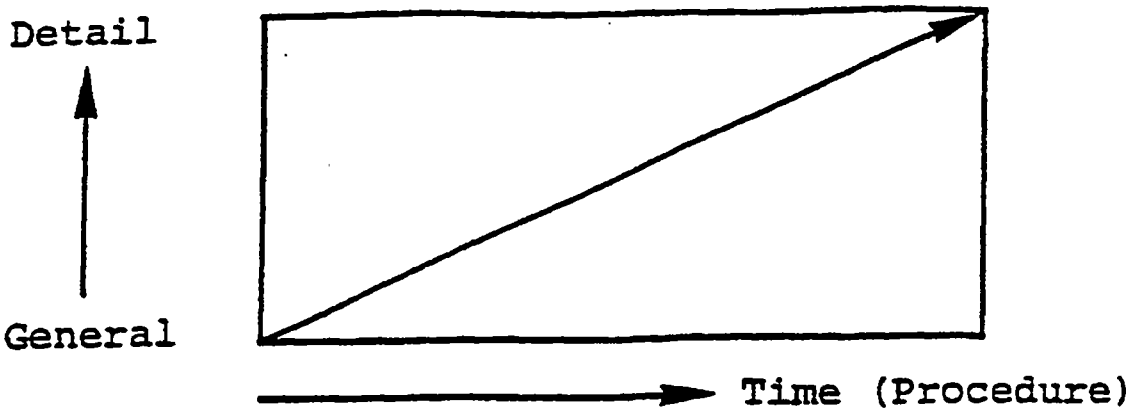
Basically, the scope and extent of every exploration procedure is governed by the following series of criteria:

- Scope of work
- Status of geological knowledge of the area to be examined
- Raw material-inherent characteristics: geological exposures, etc.
- Time and financial resources available
- Climatic conditions
- Physiography and topography of the area

2. THE "HOLDERBANK" APPROACH

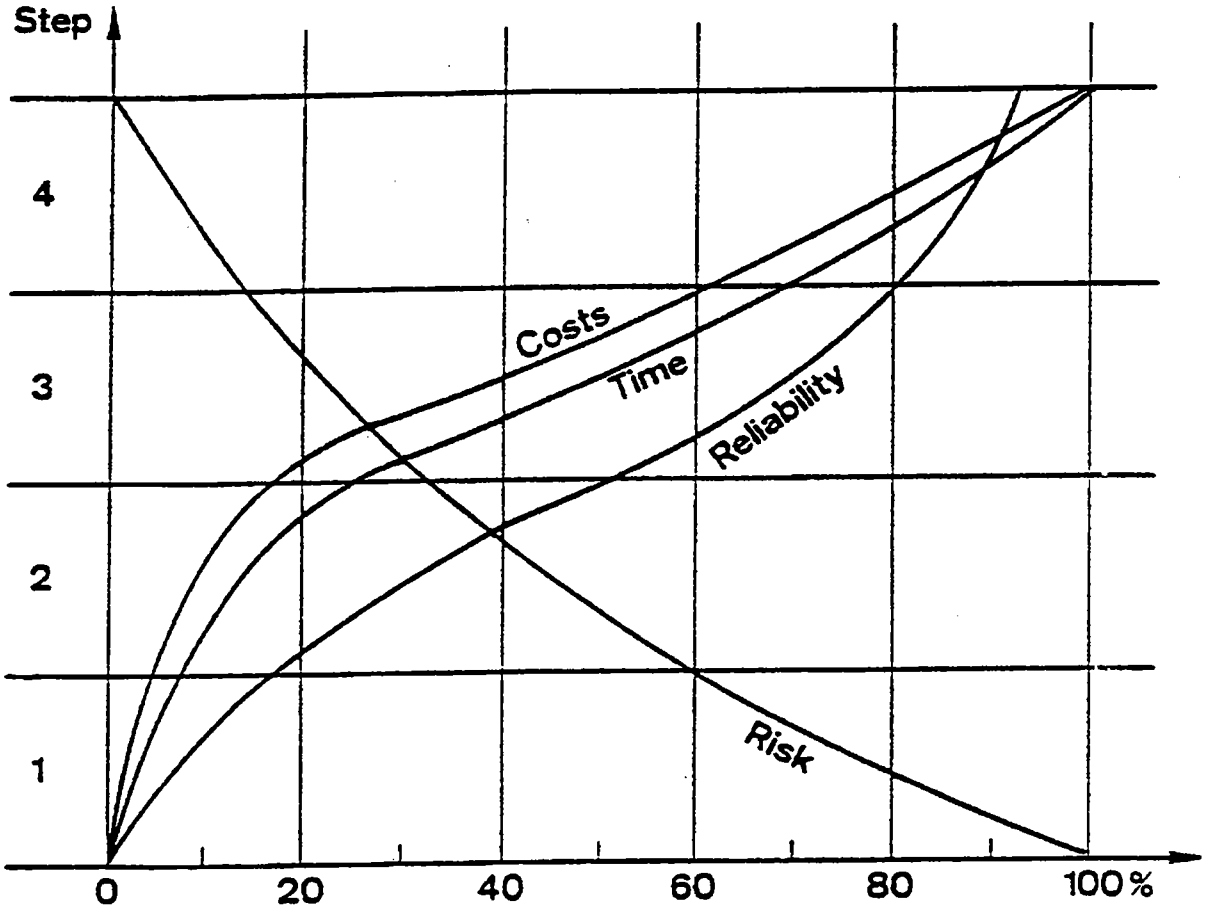
The "Holderbank" approach to recognition and exploration of raw material deposits is to proceed from a general basis to more detailed investigations (Fig. 65) continuously condensing the mass of information down to the significant details only.

Fig. 65 The "Holderbank" Approach



The procedural steps are defined with regard to their respective scope, extent, costs, time required, reliability of results (error limits) and the development of risk (Fig. 66).

Fig. 66 Development of costs, time, reliability and risk during raw material investigations.



In practice, the proposed procedure entails the following scheme:

1) desk study
2) preliminary raw materials prospecting
3) overall raw materials exploration
4) detailed raw materials exploration

2.1 Desk Study

After the preceding activities (acquisition of the project, quotation, etc.) have been completed, a fact finding study (or desk study) is conducted. The aim thereof is to acquire and evaluate all available geological, chemical and topographical facts and documents in order to generate a sound basis for subsequent investigation phases.

2.2 Preliminary Raw Material Prospecting

An initial evaluation of potential cement raw material deposits, both with regards to quality and quantity is based on existing geological maps and a suite of surface samples from the regions or areas under consideration. If the quantity or quality does not meet the

preconditions set (ie. the results are negative), the whole project is either shelved or similar investigations are initiated in other nearby regions.

Positive results, however, call for further, more thorough investigations in the promising areas. In any case, after completion of this phase, the client is to decide whether or not further investigations should be carried out.

2.3 Overall Raw Material Exploration

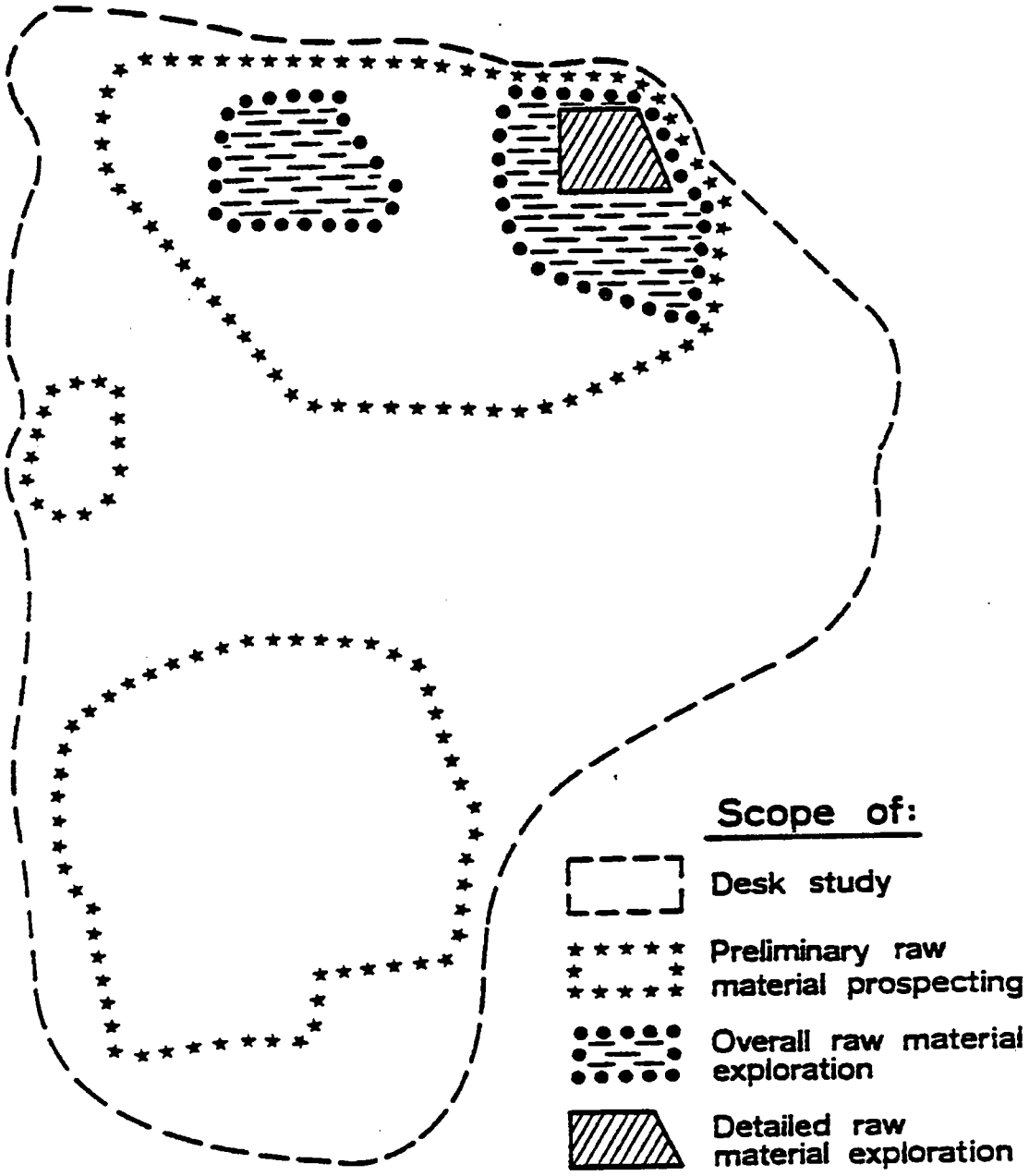
If by the above decision it was agreed to proceed, the next step would be the quantitative and qualitative characterisation of potential raw material deposits in one to three areas per raw mix component. Fresh representative raw material samples are collected from trench and/or drilling sampling. Finally, the most suitable deposits of each component are selected on the grounds of quantity, quality, accessibility, availability etc. The findings of this step of the investigation ought to be detailed enough to assess the feasibility of the project with regard to the raw material aspects.

2.4 Detailed Raw Material Exploration

After the decision - based on the overall feasibility of the project - to continue with the investigations, the selected quarry area is thoroughly investigated by drilling and subsequent quantitative and qualitative characterisation of the respective raw material areas.

In addition, a quarry exploitation scheme for all components is established.

Fig. 67 Succession of Investigation Steps.



Note: The "Holderbank" approach is described in detail in the following report:

Report MA 78/2581/E "Procedure Manual for Raw Material Investigations"

Fig. 67 displays the above described procedure for a hypothetical case.

3. COST OF RAW MATERIAL PROSPECTING AND EXPLORATION

The cost of raw material prospecting is very often perceived to be high. However it must be stressed that inadequate or worse still inaccurate knowledge of the cement raw material

deposits will certainly create innumerable difficulties during the subsequent processing stages (exploitation, preparation, processing, quality assurances).

It is obvious that the more complicated and less homogeneous a deposit is, the more thoroughly it must be investigated and the higher the costs of prospecting and exploration will be. This is especially true for low quality raw material deposits, which are situated far from market areas.

Experience has shown that the costs of a comprehensive raw material exploration campaign normally amounts to betweenUS $ 100'000 and US $ 300'000 excluding additional costs possibly required for extra drilling and geophysical surveys. A vague relationship exists between capacity, investment cost and costs for prospecting (Table 66):

Table 66: Cost of raw material prospecting versus investment costs

Plant capacity (tons of clinker per year)	Investment costs in mil (US$)	Cost quota of raw material prospecting (%) (US$)
500'000	80	0.4 - 0.6 or 400'000.--
1'000'000	150	0.3 - 0.5 or 600'000.--
2'000'000	250	0.2 - 0.4 or 750'000.--
aggregate plants tons of aggregates 500'000	15 - 20	1.5 - 2 or 300'000.--

The above figures include drilling costs, geological surveying costs etc., although it is difficult to make any general cost estimates, particularly of drilling costs, because the total length of drilling, the characteristics of the material to be drilled, the anticipated depth of the drill holes, water and power supply, transport and catering of drilling equipment and crew vary from one case to the other. The drilling costs also differ between the various countries as Table 66 a shows.

Table 66a: Cost of drilling for prospecting purposes

Country	Cost: US $ per meter
Honduras	100 - 150
Libya	300 - 400
Switzerland	100 - 250
Australia	100 - 150
Saudi Arabia	100 - 200
Viet Nam	80 - 120

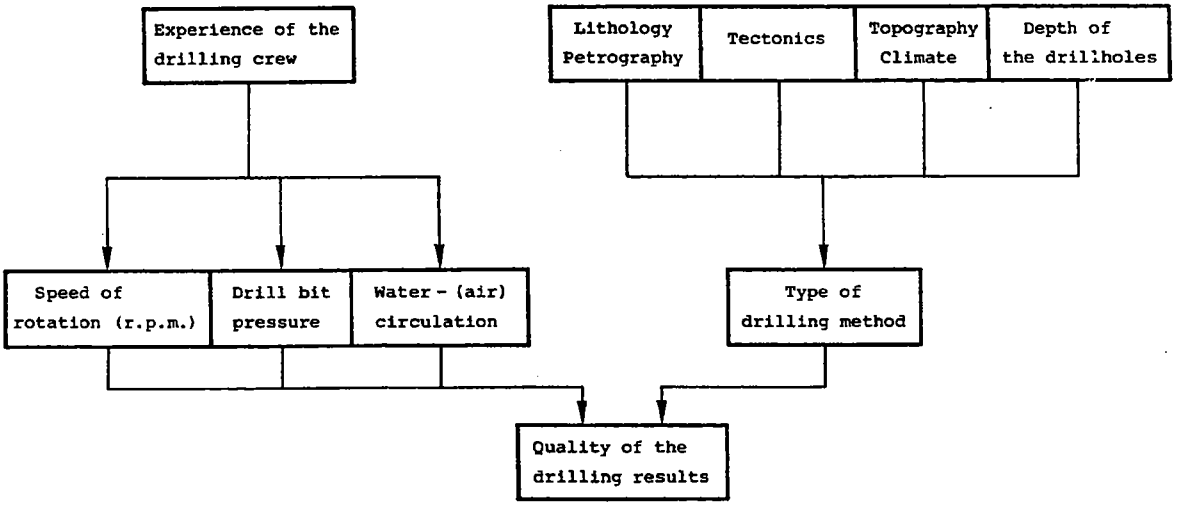
Volume of drilling required for exploration activities depends on the level of detail required. On average the following drilling quantities should normally be considered:

Overall raw material exploration 1000 m
Detailed raw material exploration 1000 - 3000 m

A break-down of the drilling costs looks like this:

Components	%
Labour	35.0
Lodging and wages for foremen	8.0
Transport on site	2.0
Drill bits	16.0
Repairs, maintenance and spares	5.0
Fuel and lubricants	3.5
Cement and rock bolts	4.5
Water supply	2.0
Annuities and depreciation	3.5
Rock samples handling and preparation	*1.0
Concession royalties, licencing & surveying	9.0
TOTAL	100

Table 70 Factors Affecting the Quality of Drilling Results



4. SIGNIFICANCE OF RAW MATERIALS INVESTIGATIONS IN PROJECTS

The term "projects" as used in this context comprises the tasks summarised in the following table:

Project	Objectives of geologist
New cement plant/aggregate plant ("grass-root-project")	Location and evaluation of potential raw material reserves
Extension of existing plant (cement or aggregate)	Verification of reserves, search for additional raw materials
Acquisition of existing (cement or aggregate)	Assessment of raw material reserves; & quarrying concept
Conversion of process mainly cement plants	Technological assessment of raw materials situation
Operational difficulties in existing plant	Search for substituting materials: & adaptation of quarrying concept
Manufacture of new cement types	Location and evaluation of new raw materials for cement type

Securing raw materials which are satisfactory with respect to quantity and quality, is the main objective in all the above cases, but in particular for the conversion / extension projects and "grass root" projects. A project could still be realised even if the market survey study does not provide conclusive results, or the infrastructure and technical concept study is not evaluated thoroughly enough. However, if the raw material investigations are not conducted with sufficient care or if pertinent results are negative, the project as a whole would not be viable.

Naturally, the raw material investigations (Table 72) are the very beginnings of a project and forms part of the feasibility phase. The feasibility phase, which is the basis of the decision whether or not a project should be continued, is followed by more detailed and specific investigation, if the go-ahead is given (Table 72).

CONCLUSION

To assess cement raw material resources means to plan and conduct the necessary investigations and to evaluate the obtained findings according to present objectives.

Table 72 Raw Material investigation as part of a complete project

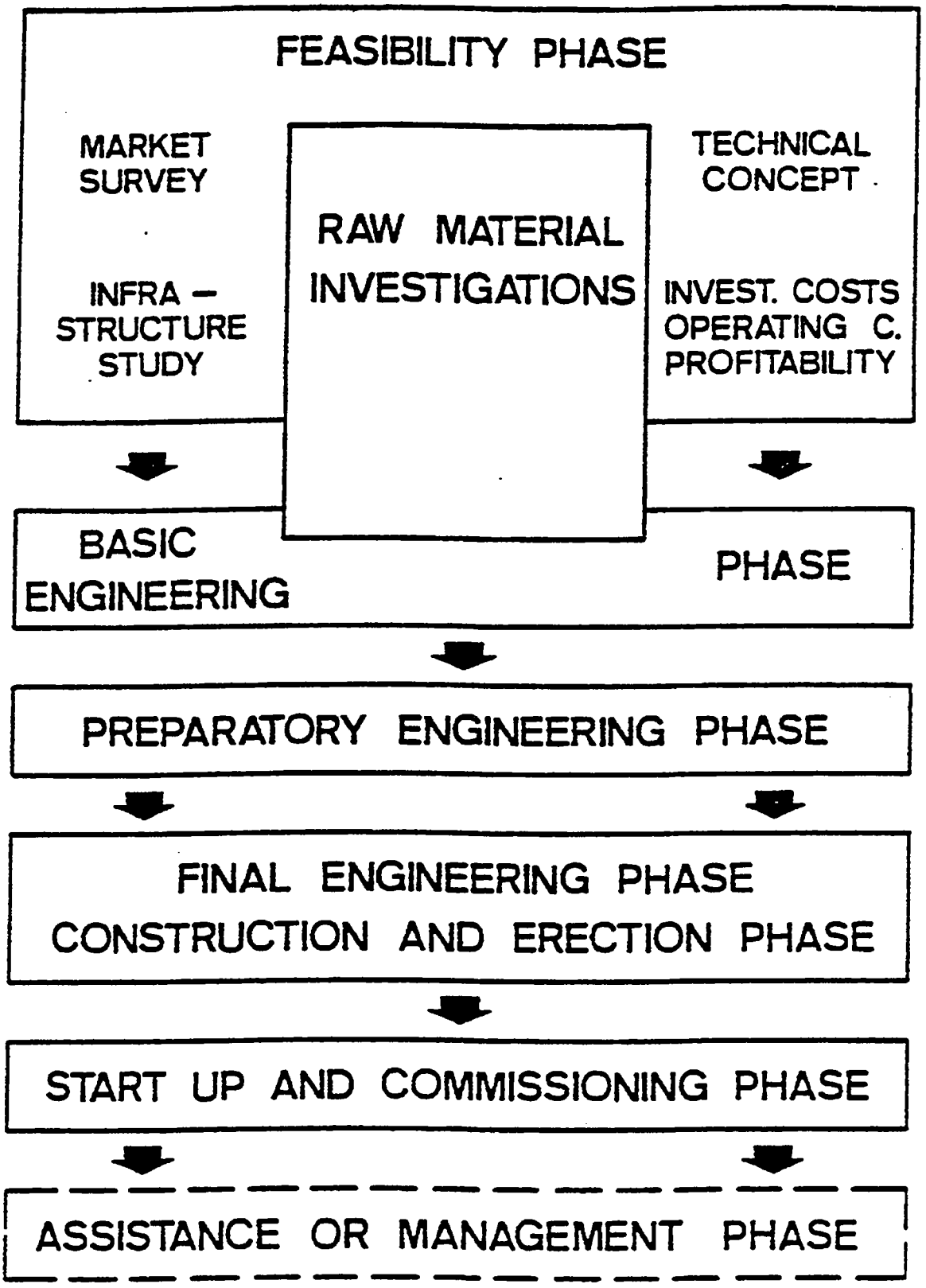


Table 73 Synopsis of the phases of a project.

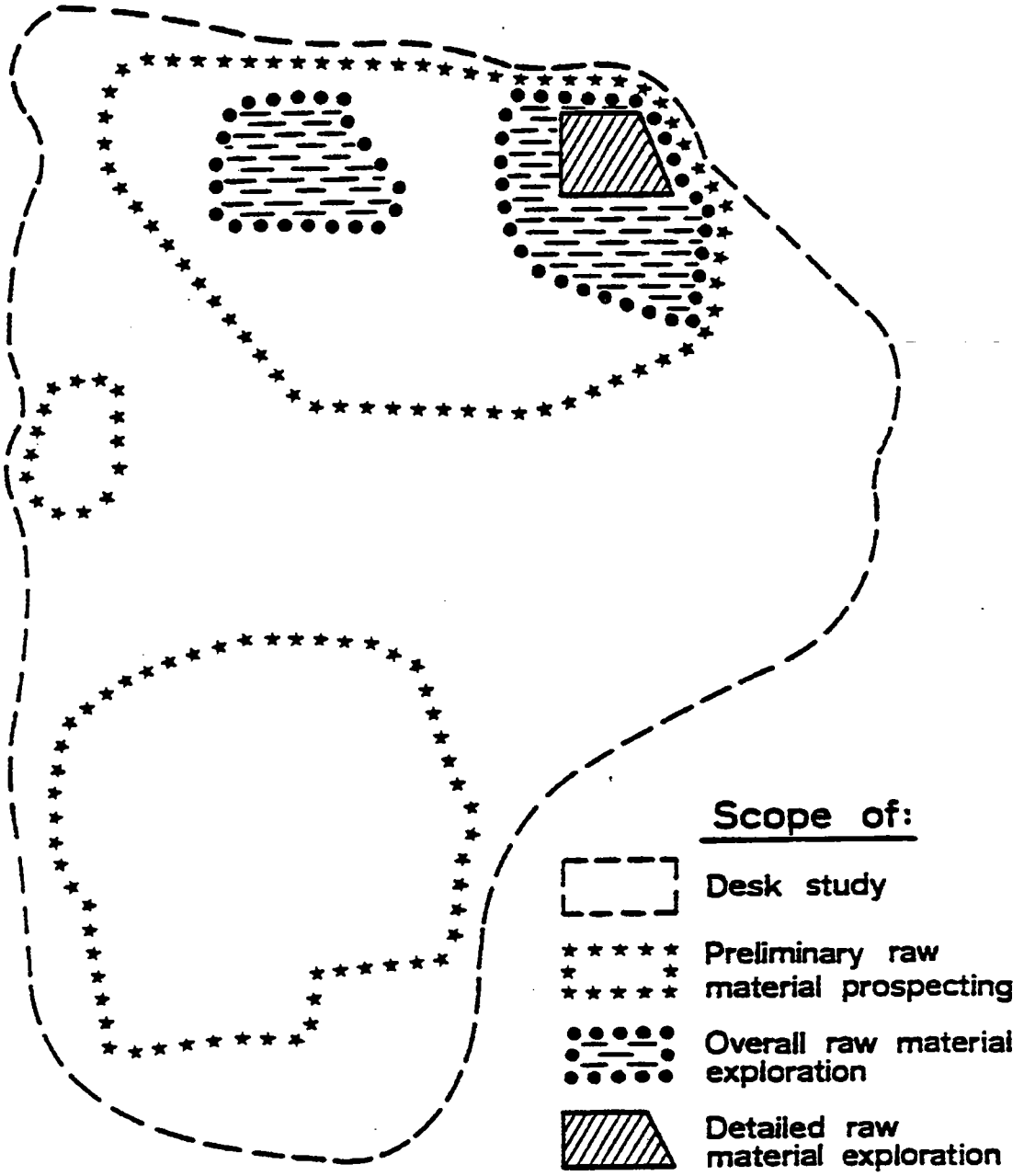
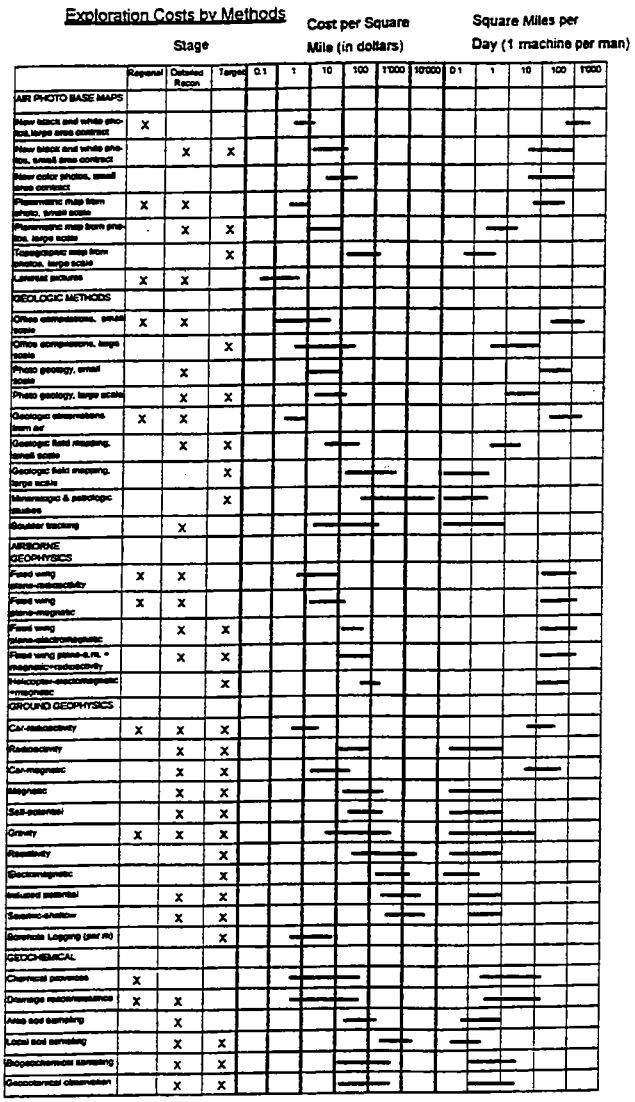


Table 74 Exploration costs by method.



2. Procedure and Scope of Services

The detailed scope of work will be set up according to the requirements of the project. The following list may serve as a guideline for services carried out in a typical project. Other services are available on request.

2.1 Step 1: Desk study

- Review and desk study of existing documents in HMC
- Compilation and evaluation of all existing documents, geological maps, aerial photographs, chemical analysis and reports which might be provided by the client
- Geological reconnaissance
- Critical examination of all acquired documents in view of the selection of deposits for investigation in the second step
- Evaluation of the results and establishment of a report

2.2 Step 2: Preliminary field investigations

- Fieldwork in the selected deposits
  - Collection of representative samples by channel sampling, pitting or trenching depending on the type of exposure
  - Geological reconnaissance field work
  - Preliminary determination of the geological structures of the deposits
- Preliminary reserves calculation
- Complete chemical cross-check analyses and determination of the mineralogical components on selected samples
- Evaluation of the chemical data
- Preliminary design of the raw mix
- Evaluation of the results and establishment of the report

2.3 Step 3: Overall field investigations

- Elaboration of technical specifications to enable the client to tender for a drilling contractor and a chemical laboratory
- Elaboration of optimal drilling programme (maximum information for minimal amount of drilling) in the raw materials deposit
- Elaboration of guidelines for lithological description of the drill hole cores, sampling of cores and sample preparation
- Initiation of the drilling campaign and permanent supervision of drilling
- Geological mapping and elaboration of the geological structure of the most suitable raw materials deposit
- Complete chemical cross-check analyses on selected samples during the drilling campaign
- Technological testing: mineralogy, grindability, abrasiveness, burnability
- Determination of the design of optimal raw mix
- Geological reserves of the deposit

GEOLOGICAL SERVICES AND RAW MATERIALS MANAGEMENT

The objective of Geological Services and Raw Materials Management is to ensure the availability of raw materials for the manufacture of cement.

The potential deposits of limestone, marl, gypsum, pozzolan or other raw materials will be investigated in order to fulfill the following requirements:

- quality suitable for cement manufacture
- sufficient reserves
- optimised quarry planning for the most economic utilisation of the deposit
- consideration of environmental impacts of quarrying

1. Services available at HMC

In order to realise prospecting in a cost effective manner, and to acquire at the same time a sound knowledge of the raw materials deposit, it is proposed to follow a stepwise approach in the exploration and evaluation work.

- **Desk study** based on the available geological maps, geological reports and if necessary satellite pictures for delimiting potential deposit of limestone.
- **Preliminary field investigations** in order to determine the quality of the limestone by surface sampling and to appraise the potential reserves.
- **Overall field investigations** on the most favourable deposit with a few drill holes and possibly geophysical measurements for the overall structural and chemical assessment of the deposit. This step will prove the feasibility of the project from a raw materials point of view.
- **Detailed deposit investigation** by means of a larger number of drill holes to establish an accurate description of the deposit. The data created will serve as a basis for a deposit inventory as calculated in the next step.
- **Computer aided deposit evaluation (CADE)** to accomplish the evaluation and interpretation of the drill hole data and all other information. The computation of a block model results in an unbiased, dependable, detailed and reproducible deposit description.
- **Quarry scheduling optimisation (QSO)** in order to use the deposit in the most economical way. This cement-specific software allows simulation of the mining development in order to ensure a steady and homogenous supply of raw materials over the longest possible lifetime, at lowest possible cost.
- **Quarry engineering and design (QED)** to make operational and environmental planning fully transparent to all interested parties involved.
- **Selection of main mining equipment** to determine the suitable size and number of units required for an efficient operation of the quarry.
- **Technological testing** confirms the suitability of the raw materials. The service is part of the overall and detailed field investigation.

To summarise, "Holderbank" Management and Consulting Ltd. offer a comprehensive range of services including all aspects of raw materials investigation and testing (in our own laboratories). The work is carried out by a team of skillful specialists (geologists, geoststatisticians, chemists, mineralogists, mining engineers, mathematicians) having a large experience in the exploration of raw materials for more than 200 cement projects.

➢Optional: geophysical measurements in order to precisely define the ore body boundaries and to determine the overburden thickness. These measurements will be carried out if necessary.

➢Comprehensive report, comprising all main results and conclusions

2.4 Step 4: Detailed deposit investigation

➢Elaboration of optimal drilling programme (maximum information for minimal amount of drilling) in the raw materials deposit

➢Permanent supervision of drilling

➢Detailed structural evaluation of raw materials deposit

➢Complete chemical cross-check analyses on selected samples during the drilling campaign

➢Technological testing: mineralogy, grindability, abrasiveness, burnability

➢Determination of the design of optimal raw mix

➢Geological reserves of the deposit

➢Optional: geophysical measurements in order to precisely define the ore body boundaries and to determine the overburden thickness. These measurements will be carried out if it is necessary.

➢Comprehensive report, comprising all main results and conclusions

2.5 Computer aided deposit evaluation (CADE)

➢Statistical evaluation of drill hole data

➢Computation of block model

➢Calculation of reserves in terms of raw mix

➢Deposit display by means of coloured perspective views

➢Development of strategic medium and long-term mining plans

2.6 Quarry scheduling optimisation (QSO)

- Software licence
- Implementation and training on site
- Development of detailed mining plans
- Production scheduling and control

2.7 Quarry engineering and design (QED)

- Optimal open pit design
  - slope angle, bench geometry
  - number of benches
  - haul ramps
  - access road
  - crusher location
  - camouflage walls
- Detailed maps
- Visibility analysis
- Realistic perspective views of quarry development and rehabilitation
- Computer animation

2.8 Selection of main mining equipment

- Type and size of trucks
- Type and size of crusher
- Investment and operation costs

2.9 Technological testing

- Mineralogical composition
- Grindability of raw materials and raw mix
- Abrasiveness of components
- Burnability of raw mix
- Other tests as required